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Identification of tropospheric BrO column densities from satellite measurements and their relation to meteorological parameters

H. Sihler (1,2), T. Wagner (2), C. Hörmann (1,2), S. Beirle (2), S. Dörner (2), U. Frieß (1), and U. Platt (1)
(1) University of Heidelberg, Institute for Environmental Physics, Heidelberg, Germany, (2) Max Planck Institute for Chemistry, Mainz, Germany

Bromine monoxide (BrO) radicals are known to play an important role in the chemistry of the springtime polar troposphere. Their release by halogen activation processes frequently leads to the almost complete destruction of near-surface ozone during “ozone depletion events” (ODEs), which may cover areas of up to several thousand square kilometres. The autocatalytic mechanisms, called Bromine Explosion, leading to halogen activation from saline surfaces, such as frost flowers and brine, are not well understood yet. Consequently, several theories explaining the evolution and dynamics of bromine activation exist in the literature. Here we compare the ability of some of these theories to explain our observations from space.

While UV/vis-satellites can not readily resolve the vertical distribution of BrO in the troposphere and have rather coarse horizontal resolution (GOME-2: 80x40 km), they may still provide important information on the large-scale horizontal distribution of BrO. A new algorithm is presented, which allows separation of the fraction of BrO in the activated boundary layer from the total BrO column solely based on properties remotely measured by satellite. Our approach encompasses a careful study of the radiative transfer properties of the analysed atmosphere in order to assure sensitivity for BrO in the boundary layer. The algorithm also delivers a statistical measure for the significance of bromine activation in the boundary layer, which may be used to investigate the correlation between bromine activation and other observable quantities.

Vertical tropospheric columns of BrO are compared with surface observations from two field campaigns conducted within the OASIS project in 2008 and 2009. A correlation coefficient of r^2=0.62 between surface observation and satellite data indicates that satellites are suitable to study surface processes. Furthermore, our approach allows to use satellite observations to study bromine activation on a more general scope and for extremely large data sets (in contrast to ground-based studies, which have to concentrate on special events).

We investigate tropospheric BrO column densities in relation to meteorological parameters, i.e. ECMWF wind fields and surface temperature, and surface properties. We found a bimodal dependence of BrO on these two parameters: The probability to observe a significantly increased BrO column during the beginning of the season increases for temperatures below -20°C but is found to be almost independent from the wind speed. Later in the season, from April on, the probability is significantly higher for temperatures around -10°C and positively correlated to the surface wind speed. This indicates that bromine activation occurs in different ways and that a single hypothesis may not consistently explain the physical properties behind bromine related ODEs for the entire season.